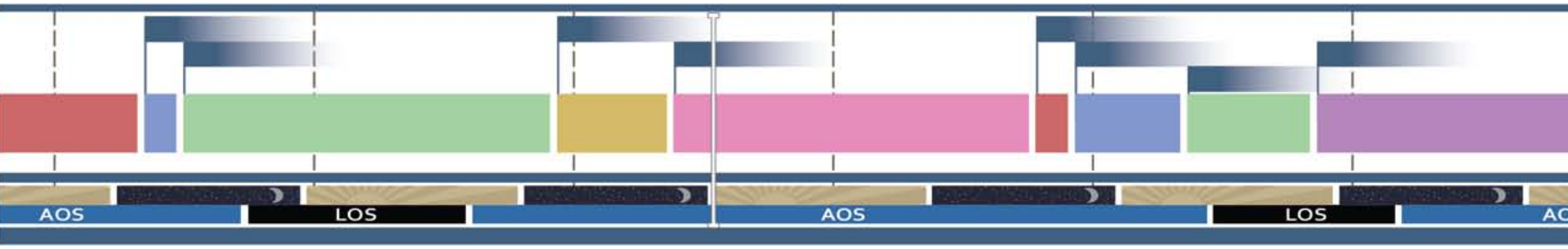



Console Handbook

# CRONUS

## Communication Radio Frequency Onboard Network Utilization Specialist

The CRONUS (pronounced *crow-nus*) flight controller manages the transfer of data (or information) between communication satellites which orbit the Earth, the International Space Station (ISS), ISS crewmembers, space vehicles visiting the ISS and the Mission Control Center (MCC). Data managed by this flight controller includes command uplinks (transmission of signal from the MCC to the ISS), file transfers and information about the ISS or its crew (such as temperature, pressure, voltage, equipment, station position and attitude, and video or audio communications). This person also ensures important data is stored.

The CRONUS flight controller also provides Information Technology (IT) support by administering computer software updates to the ISS and ensuring the United States (U.S.) portion of the ISS computer network systems and crew laptops are functioning properly.

Finally, the CRONUS flight controller is responsible for running and maintaining the Caution and Warning (C&W) server, which warns the ISS crew and the MCC of any conditions that may negatively affect operations) for the Flight Control Team (all console positions), located within the MCC.

# CRONUS

Communication Radio Frequency Onboard Network Utilization Specialist

Systems Managed: Command and Data Handling System, S-band Communications System, Ku-band Communications System, Ultra High Frequency Communications System, Internal Audio System, Video Distribution System and Outage Recorder Systems

## Command and Data Handling System

*How is information handled between the MCC and the ISS?*

The CRONUS flight controller operates the entire ISS Command and Data Handling (C&DH) system, which mainly consists of computer systems. These responsibilities include uploading new software and transferring data files between the MCC and the ISS. The CRONUS flight controller will assist with these potential issues, and he or she will also inform fellow flight controllers of any problems with, or changes to, the C&DH system.

### Sending and Accessing Data

*How are ISS systems operated and monitored?*

Each flight controller in the MCC is able to create and send commands through the C&DH system. These commands are forwarded to the proper ISS system and are used to either keep ISS systems functioning properly, or to change how a system is operating.

The CRONUS flight controller will periodically downlink command history logs that contain every command executed onboard that was generated either from the ground, the crew or by onboard software. Should a problem or question arise, the CRONUS flight controller can create a command history, providing a detailed look at any uplinked or executed command for any specific period of time.

In the event there is a problem sending (uplinking) commands from the MCC in Houston to the ISS through U.S. communications assets, these commands can be uplinked to the ISS through the communication assets in the MCC in Moscow, Russia (MCC-M). This is the U.S. segment's back-up communications path.

### Computer Systems

*What hardware and software is required to operate the ISS?*

The U.S. segment on the ISS has a large computer network which controls various ISS subsystems. The individual computers in this network are called Multiplexer/Demultiplexers (MDMs). MDMs take a large number of input signals, processes them and formats them for transmission across the computer network.

There are 46 Multiplexer/Demultiplexer (MDM) computers onboard the U.S. segment of the ISS, all which control various ISS subsystems. They are located inside or outside the ISS modules, or are located on the truss of the ISS (the structure which connects the ISS solar arrays).

Each MDM computer has specific software needed to operate an ISS subsystem. For example, all commands sent to the ISS are first received by the Command and Control (C&C) MDM. The C&C MDM then forwards each command to the specific MDM which controls that targeted subsystem, such as internal communications, external cameras or specific pressure sensors.

### Timekeeping

*How do the ISS computers stay synchronized?*

The ISS time standard is the same as Global Positioning System (GPS) time. The CRONUS flight controller manually inputs time updates and corrections to the C&C MDM. This keeps the C&C MDM time as close to GPS time as possible, which is important for scheduling and position knowledge of the ISS. This time correction is then distributed to all ISS MDMs so that they remain in sync. The CRONUS flight controller also maintains time synchronization between the ISS computers and the MCC.

To learn more about GPS time as it relates to the ISS and space, visit http://www.gps.gov/applications/space/.

### Portable Computers

*How are the crew's laptops maintained?*

The CRONUS flight controller is responsible for proper function of the U.S. Portable Computer System (PCS). The PCS laptop is how the crew interfaces to the C&DH System. This responsibility includes ensuring all laptop hardware and software is updated. If a failure occurs with one of the portable crew computers, the CRONUS flight controller provides technical support to assist the crewmember in successfully completing the time-lined tasks.

## S-band Communications System

*How does the MCC communicate with the ISS?*

The S-band communications system consists of two sets of specialized computers and is used by the MCC flight controllers to send commands from the MCC to the ISS. It uses radio waves with frequencies that range from 2 to 4 gigahertz (GHz). (One GHz equals a frequency of one billion cycles, or wavelengths, per second).

Data is collected, stored and sent down (or downlinked) from the ISS to the MCC during a certain time based on order of importance. This is necessary because there is simply too much data created at any given time on ISS to fit down the S-band stream bandwidth. These computers, referred to as Group 1 and Group 2, encode information within each stream of data being downlinked to the MCC from the ISS, ensuring a more robust data transmission. Data uplinked from the MCC to ISS in encoded for additional security purposes. Likewise, these computers also assist in decoding this data.

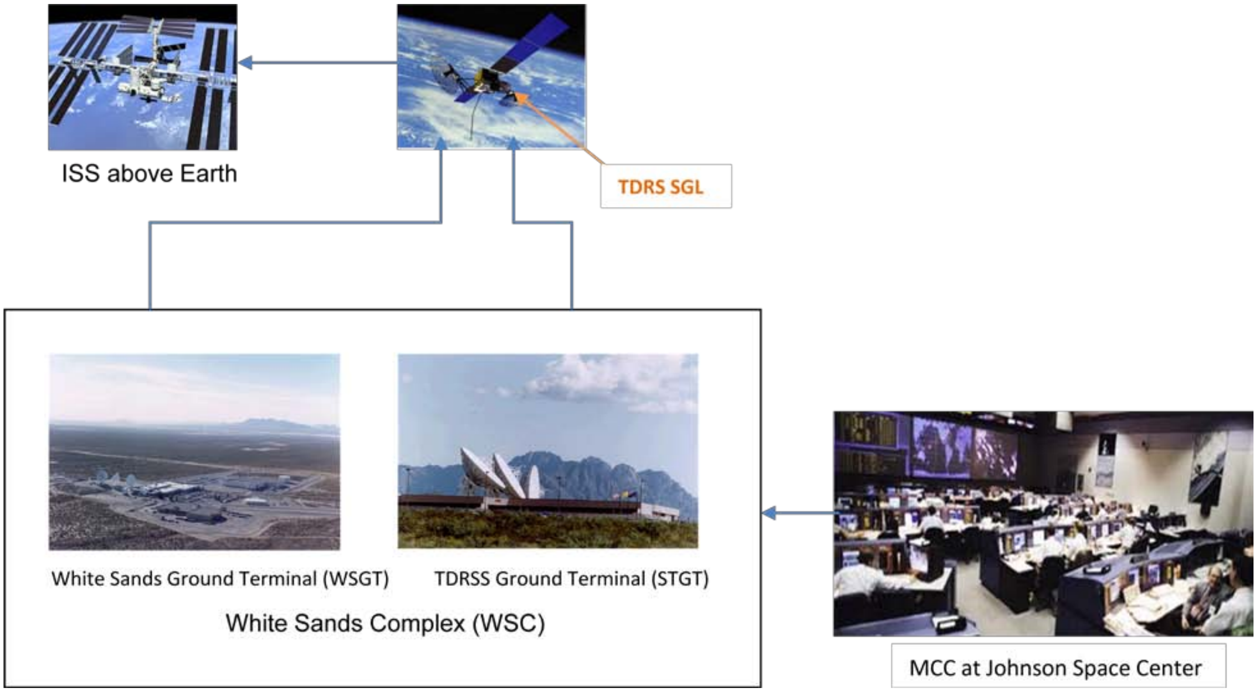
### Communication and Tracking

*How are commands and data sent between the MCC and ISS?*

Ground terminals in the MCC provide the hardware and software necessary to ensure uninterrupted communications between the ISS and MCC. They relay signals to and from Tracking and Data Relay Satellites (TDRS). Each TDRS has a Space-to-Ground Link (SGL) antenna which relays voice, video, systems and research cargo data, and command uplinks and downloads between the ISS and MCC.

The MCC sends commands to two functionally-identical off-site ground terminals at the White Sands Complex (WSC), located in Las Cruces, New Mexico. These terminals are called the White Sands Ground Terminal (WSGT) and the Second TDRSS Ground Terminal (STGT). (TDRSS stands for Tracking and Data Relay Satellite System.)

This satellite system consists of six Tracking and Data Relay Satellites (TDRS), which orbit the Earth above specific longitudes. Depending on which WSC ground terminal is operational, the active commands from any user can be uplinked to a TDRS.




Flow of communication from the MCC to the ISS

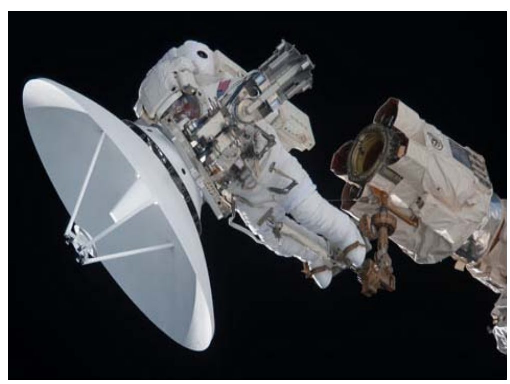
An S-band antenna on the ISS will search to exchange data with the SGL antenna and an in-range TDRS, which is scheduled for use by the ISS. The S-band antenna must be active and transmitting, and pointed in the right direction of the nearest TDRS. Therefore, the S-band antennas are attached to motorized gimbals (located on the truss of the ISS), which allow the antennas to be moved into the correct position for data exchange.

For more information about the TDRSS, visit http://tdrs.gsfc.nasa.gov/ or https://www.spacecomm.nasa.gov/spacecomm/programs/tdrss/default.cfm.

## Ku-band Communications System

*How does ISS have video communication?*

The Ku-band communications system collects, converts, packets and transmits video and recorded ISS systems data between the ISS and the nearest TDRS. Multiple channels of live and recorded data are combined (multiplexed) with compressed video files and then transmitted (downlinked) to a TDRS through a Space-to-Ground Ku-band antenna. Similar to S-band antennas, gimbals are required to correctly point the Ku-band antenna to the satellite.



Pictured is NASA astronaut Garrett Reisman (STS-132) during a spacewalk to install a second antenna for high-speed Ku-band transmissions.

The Ku-band system also supports video teleconferencing and the transfer of data files from the MCC to the ISS. Ku-band can also be used as a back-up if the primary S-band voice communications system is down.

From the satellite, the downlinked data can be sent to the flight controllers in the MCC, to research cargo specialists located at the Marshall Space Flight Center (in Huntsville, Alabama); or to International ISS Partners at the Japan Aerospace Exploration Agency (JAXA) or the European Space Agency (ESA).

## Ultra High Frequency Communications System

*How does a crewmember performing a spacewalk communicate with the ISS?*


Astronaut Dave Wolf (STS-127) is pictured next to a UHF antenna on the P1 Truss of the ISS during a spacewalk.

The Space-to-Space Station Radio (SSSR) consists of two computers (primary and back-up) located in the U.S. Lab Module, and four redundant external antennas (two per radio) co-located on the US Lab Module and the P1 (Port) Truss (pictured left).

The SSSR transmits through the Ultra High Frequency (UHF) system, which is a Space-to-Space communications system with the capability to transmit and receive voice commands and data between the ISS and a crewmember performing a spacewalk. Only one of the UHF channels can be used at a time since only one SSSR is active at a time.

## Internal Audio System

*How is audio communication achieved?*

The Internal Audio System (IAS) is a complex system which distributes audio communication throughout the ISS, to the ground, and to crewmembers during spacewalks. The IAS also broadcasts Caution and Warning (C&W) alerts throughout the U.S. portion of the ISS using different sets of audible tones. Each set of tones relates to a specific caution or warning message and each have different meanings. The CRONUS flight controller understands what the different tones mean and which responsive actions to take.

The IAS is controlled by the Internal Audio Controller (IAC). The IAC can be thought of as “the brains” of the audio system. It provides two-way (or conference call) communications, which is the normal method for communication on the ISS.


Audio Terminal Unit (ATU)

Crew Communications Headset Assembly (CCHA)

Crew audio communications are distributed through a network to individual audio terminal units (ATUs), which are essentially telephones, located throughout the ISS. The ATUs are critical because they are also responsible for broadcasting the C&W tones generated by the Internal Audio Controller (IAC).

Each ATU has a built-in speaker and microphone, and includes a portable hand-held microphone *(pictured right)* or a headset assembly *(pictured left)* which can be connected together for hands-free use.

Since the Russian Audio System is very different from the IAS, the IAS includes a Russian Audio Interface Unit (RAIU) which provides a link to the Russian Audio System.

Hand-held microphone which attaches to the ATU

## Video Distribution System

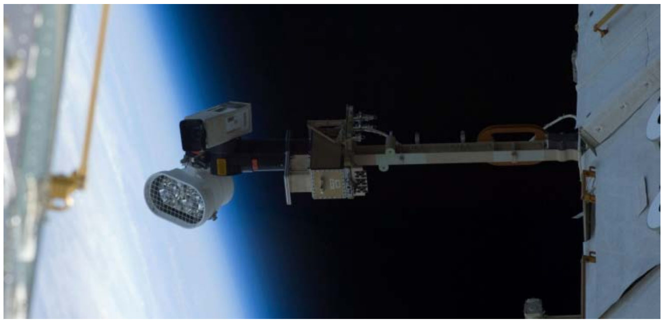
*How is information from the ISS cameras viewed and shared?*

The Video Distribution System (VDS) provides a way for the crew, the MCC, Payload Operations Center (where cargo operations take place), and ISS International Partners to take camera data and generate, distribute and display videos. Video signals are distributed on individual lines, or links, from the camera source to where the video is displayed using the Ku-band communications system.

The VDS uses video distribution switches to provide the ability to send camera control commands, generate test signals, merge two source images into one output and record/playback video signals from the video tape recorders.

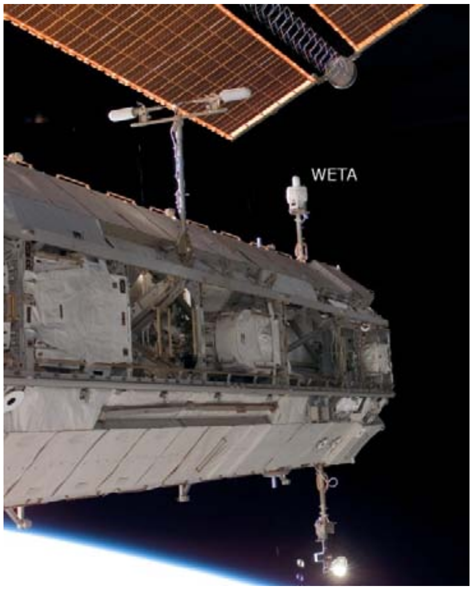
A Video Tape Recorder (VTR) is generally used when there is no Ku-band service available to downlink live video. Two VTRs are located in the U.S. Lab Module and can provide two hours of recording time from any video source. They can be controlled from the ground or onboard by the ISS crew.

The External Television Camera Group (ETVCG) forms "the eyes" outside the ISS. There are currently four ETVCGs located on the outside of the U.S. Lab Module, two on the P1 (Port) truss and one on the S1 (Starboard) truss. The ETVCG have typical camera functionality of shutter, zoom, focus and iris controls. However, they also have pan and tilt functionality which allows them to move in all directions, but with a different reference frame. In addition, each camera is equipped with a light assembly for orbit night operations.



An ETVCG mounted outside the ISS

The Wireless Video System (WVS) consists of three external antennas called Wireless External Transceiver Assemblies, or WETAs. A WETA *(pictured below left)* can receive video signals wirelessly from an Extravehicular Activity (EVA) suit camera called an Extravehicular Mobility Radio Frequency Camera Assembly, or ERCA. A WETA can also send commands to move or adjust an ERCA *(pictured below right)*.




Wireless External Transceiver Assembly (WETA)


Extravehicular Mobility Radio Frequency Camera Assembly (ERCA)

## Outage Recorder Systems

*How is data recorded and played back?*

There are two different systems for recording and playing back data. The first resides within the C&C MDM called the Ops Recorder. This recorder records all data currently selected for downlink and works in a looped fashion, recording over the oldest unlocked (unheard) data. This recorder has the ability to lock timeframes of data for playback. Locking the data insures that new data does not record over the desired data. An automated ground tool is used to command the C&C MDM to playback all periods of no communications, or Loss of Signal (LOS). (A LOS can occur for several reasons – most likely the TDRS time is not scheduled or available.)

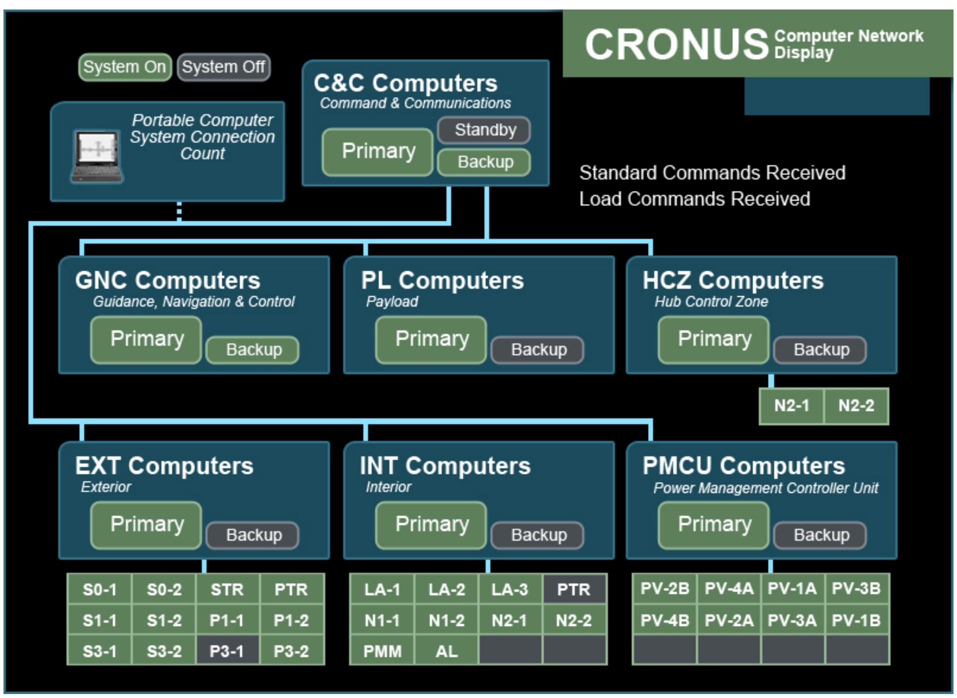
After each LOS, the ground software commands the C&C to lock the data for the duration of the LOS. It then plays back this data through a Ku-band payload channel at much faster rates. The data is collected on the ground in a database for future needs. Once the data is confirmed on the ground, the timeframe in the Ops Recorder is unlocked, freeing it up for new data to be recorded.

The second recorder is called the High Rate Outage Recorder (HCOR). The HCOR sits in line between various kinds of research equipment and the Ku-band High Rate Frequency Multiplexer (HRFM), which combines many different research cargo data channels and video data channels into one stream of information. This recorder provides eight channels of recording and can playback data on two channels at once. Data can simply be passed through the HCOR when there is a Ku-band link available. The research cargo community uses the HCOR the most in order to record critical science data during Ku-band LOS.

To learn more about ISS communications systems, return to the ISS*Live!* website at http://www.spacestationlive.jsc.nasa.gov. Select “Interact”, and then select “Visit Space Station”.

## CRONUS Console Displays

A wireless signal sends data from the ISS to the Mission Control Center. This data is updated on the CRONUS console displays. The CRONUS flight controller checks the data on the console displays to make sure that data is uplinked and downlinked correctly between the ISS and the MCC.



Pictured above is a simplified version of the CRONUS console display. To view this display, return to the International Space Station *Live!* (ISS*Live!)* website at http://www.spacestationlive.jsc.nasa.gov. Select “Interact”, and then select “Explore Mission Control”.

## Space Station Live Data

Would you like to know more about the live data streaming from the ISS to the CRONUS console displays? Return to the ISS*Live!* website at http://www.spacestationlive.jsc.nasa.gov. Select “Resources”, and then select “Space Station Data”. There you will find a table which includes the names and brief descriptions of all the data values used to update the interactive Mission Control Center console displays.

## Acronyms and Abbreviations

| | |
|---|---|
| ATU | Audio Terminal Units |
| C&C MDM | Command and Control Multiplexer/Demultiplexer |
| C&DH | Command and Data Handling |
| CRONUS | Communication Radio Frequency Onboard Network Utilization Specialist |
| C&W | Caution and Warning system |
| ERCA | Extravehicular Mobility Radio Frequency Camera Assembly |
| ESA | European Space Agency |
| ETVCG | External Television Camera Group |
| EVA | Extravehicular Activity |
| GHz | Gigahertz |
| GPS | Global Positioning System |
| HCOR | High Rate Outage Recorder |
| HRFM | High Rate Frequency Multiplexer |
| IAC | Internal Audio Controller |
| IAS | Internal Audio System |
| ISS | International Space Station |
| IT | Information Technology |
| JAXA | Japan Aerospace Exploration Agency |
| LOS | Loss of Signal |
| MCC | Mission Control Center |
| MDM | Multiplexer/Demultiplexer computer |
| PCS | Portable Computer System laptop |
| RAIU | Russian Audio Interface Unit |

| | |
|---|---|
| SGL | Space-to-Ground Link |
| SSSR | Space-to-Space Station Radio |
| STGT | Second TDRSS Ground Terminal |
| TDRS | Tracking and Data Relay Satellite |
| TDRSS | Tracking and Data Relay Satellite System |
| UHF | Ultra High Frequency |
| U.S. | United States |
| VDS | Video Distribution System |
| VTR | Video Tape Recorder |
| WETA | Wireless External Transceiver Assembly |
| WSC | White Sands Complex |
| WVS | Wireless Video System |
| WSGT | White Sands Ground Terminal |

## Glossary of Terms

| | |
|---|---|
| Attitude | The three-dimensional position of a spacecraft in relation to another point. Also called orientation. |
| Bandwidth (or stream bandwidth) | The width of the range (or band) of frequencies that an electronic signal uses on a given transmission medium. |
| Demultiplexer | A computer that has a single-input and multiple-output switches. |
| Frequency | Amount of wavelengths cycle per second. |
| GHz | A frequency of one billion cycles or wavelengths per second. |
| Gimbal | A device with two mutually perpendicular and intersecting axes of rotation, thus giving free angular movement in two directions. |
| Multiplexer | A computer that has multiple-input signals and a single-output switch. |
| Teleconferencing | The holding of a conference among people remote from one another by means of telecommunication device. |